rapid evaluation. Further, in the method, a movable sample stage permits arbitrary selection of the region and position of measurement.

Further, with variable monitoring wavelength, the method of measurement of dislocation density by means of PL mapping is applicable to a wide range of crystal composition. The wavelength for the PL intensity monitoring is generally set to be the main peak wavelength in the PL light. When a plurality of PL peaks each having a diverse wavelength are emitted from a plurality of layers in a multi-layer epitaxial crystal, mapping can be carried out in each wavelength. This gives the dislocation density in each layer and hence information on the change in dislocation density.

The laser light used for the excitation in PL mapping needs to have a photon energy greater than the band gap energy of the crystal. Any kind of laser satisfying this requirement can be used. For example, lasers applicable to GaAs, AlGaAs, and InGaAs are an Ar laser and a secondary harmonics YAG laser. Further, for nitride semiconductors such as GaN and InGaN, a HeCd laser can be used preferably.

It is important to set the PL mapping conditions, especially, laser spot size, measurement point spacing, and measurement region area, appropriately to the size and thickness of dislocations (dark spots and dark lines) to be detected by PL. The size of dark spots is in the order of photo-carrier diffusion

length which is characteristic to the crystal.

The laser spot size is preferably set to be in the order of the size of dark spots, or the photo-carrier diffusion length. Even when the laser spot size is smaller than the photo-carrier diffusion length, the carriers generated by the laser irradiation diffuse into a region in the order of photo-carrier diffusion length. This prevents the improvement in spatial resolution. In contrast, inappropriately large laser spot size causes degradation in spatial resolution and PL signal intensity, thereby undesirably increasing the noise.

With dark spot size d (μm) and laser spot diameter D (μm), preferable laser spot diameter is in the order of $0.1d < D < 30d$. Thus, the preferable laser spot diameter is 1-100 μm for GaAs and AlGaAs semiconductor crystals and the like, and 0.3 μm to a few μm for GaN and InGaN semiconductor crystals and the like.

Measurement point spacing is preferably set to be in the order of laser spot diameter or smaller. A measurement point spacing greater than the laser spot diameter prevents the measurement of overall surface, and hence is undesirable. A measurement point spacing smaller than the laser spot diameter gives more detailed intensity distribution. Nevertheless, an extremely small measurement point spacing causes an extremely long measurement time, and hence is undesirable. Preferable measurement point spacing L is in the order of $0.01D < L < D$.

The method of counting the dark spots may be any of the method of direct counting from the map, the method of image analysis, and the like.

Measurement region area is set to be an appropriate size depending on the dislocation density of sample, that is, the density of dark spots and dark lines. The preferable number of dark spots is 1-1000, while the preferable number of dark lines is 1-100. Numbers outside these ranges can cause a problem in counting accuracy. Thus, the measurement region area is preferably set so that the counted numbers fall within the ranges. From the measurement region area ($S\ cm^2$) of PL mapping and the counted number (n) of dark spots or dark lines, the dislocation density ($N\ cm^{-2}$) is obtained according to the following formula.

$$N = n/S$$

EXAMPLES

The invention is described below in detail but it should be noted that the invention is not restricted to these examples.

Example 1

The 3-5 group compound semiconductor epitaxial multi-layers (buffer layer 3) having the superlattice structure shown in Figure 1 were grown on the (100) surface of a GaAs substrate by means of OMVPE. After the growth of the buffer layer 3, the epitaxial crystal layers (optical device layer 4) of double heterostructure were grown for the PL measurement.